Memorandum

To: Bud Abbot, Strategic Environmental Consulting
Mike Blankinship, Blankinship and Associates

From: Lawrence Spurgeon, Parsons Brinckerhoff

Date: July 5, 2001

Subject: Detonation Cord Noise Levels for Lake Davis Study

To assess noise impacts on surrounding wildlife and people from the proposed detonation cord blasting for fish removal it is necessary to determine the noise level from the blast. Empirical noise data from underwater use of detonation cord is not available; therefore, a survey of individuals who had witnessed blasting was undertaken to determine a range of likely noise levels.

Strategic Environmental Consulting prepared a survey form that requested information on blasting conditions and provided a range of noise sources that the blasting noise level could be compared to. Seven individuals with experience in underwater use of detonation cord responded to the survey. The blasting conditions and situation experienced by the respondents was varied. Conditions ranged between 2 and 50 feet of water and various types and amounts of detonation cord. The reported experience, based on comparison to other noise sources; however was very similar for most respondents (Table 1). Given the nature of human hearing in responding to high-level impulse noise, the reported values roughly represent the Peak or Lmax noise level with a C-weighting. C-weighting is a standard frequency weighting that simulates the response of the human ear to high amplitude (loud) noise. The Peak noise level is the highest instantaneous noise level, while Lmax is the highest short-duration time weighted noise level. Peak levels are always slightly higher than Lmax levels; however, Lmax generally better describes how humans respond to short-duration noise events. The reported noise values will be interpreted as Lmax (dBC).

Table 1. Reported Noise Conditions

Number	Distance Reported	Estimated Noise Range
1	300 feet	70 dB
2	100 feet	80-85 dB
3	60 – 120 feet	85-95 dB
4	50 feet	100-110 dB
5	100 feet	80-90 dB
6	600 feet	90-95 dB
7	100 feet	50 dB

The reported results were normalized to a distance of 100 feet from the event. Because of the subjective nature of the reporting, the highest and lowest reported values were also eliminated (Table 2).

Table 2. Normalized Noise Levels at 100 feet

Number	Estimated Noise Range
1	80 dB
2	80-85 dB
3	85-95 dB
4	90-100 dB
5	80-90 dB

A wide variety and quantity of detonation cord were reported, with incomplete description in several cases. A reasonable condition that is within the range of conditions experienced in the above cases is 1 to 2 strands, 100 feet long of detonation cord approximately 2 feet below the surface, with the estimated noise level [Lmax (dBC)] 100 feet from the nearest point.

Using the data described above, a conservative estimate of an Lmax noise level of 100 dBC at 100 feet from the nearest detonation cord placement for each two strands of 100 foot length can be assumed. The most likely noise level would be approximately 10 dBC (90% less noise energy) below this value.

To calculate actual noise levels over distance from the source, the noise level for the proposed firing condition shall be calculated at the reference distance of 100 feet using the assumption of 100 dBC for two strands of 100 foot length. This noise level will then be propagated to the distance of interest using noise propagation equations. As a rough estimate, noise levels at 100 feet would increase by 3 dBC for each doubling of the source strength (2 strands to 4 strands, then 4 strands to 8 strands). Noise levels would then decrease by 6 to 8 dBA for each doubling of distance from the source (100 feet to 200 feet, then 200 feet to 400 feet).

Memorandum

To: Bud Abbot, Strategic Environmental Consulting
Mike Blankinship, Blankinship and Associates
Julie Cunningham, California Department of Fish and Game

From: Lawrence Spurgeon, Parsons Brinckerhoff
Ginette Lalonde, Parsons Brinckerhoff

Date: September 6, 2001

Subject: Detonation Noise Levels Estimated At Distance From Lake Davis

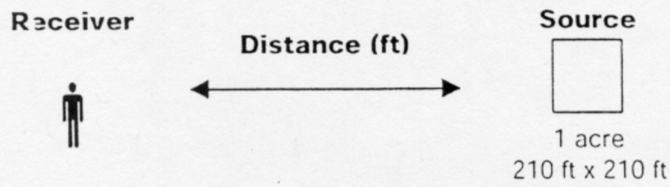
To assess noise impacts on surrounding wildlife and people from the proposed detonation cord blasting for fish removal it is necessary to estimate the noise level from the blast. Using the data described in the previous memorandum "Detonation Cord Noise Levels for Lake Davis Study" dated July 5, 2001, a baseline for noise levels resulting from underwater explosions was estimated.

Methodology

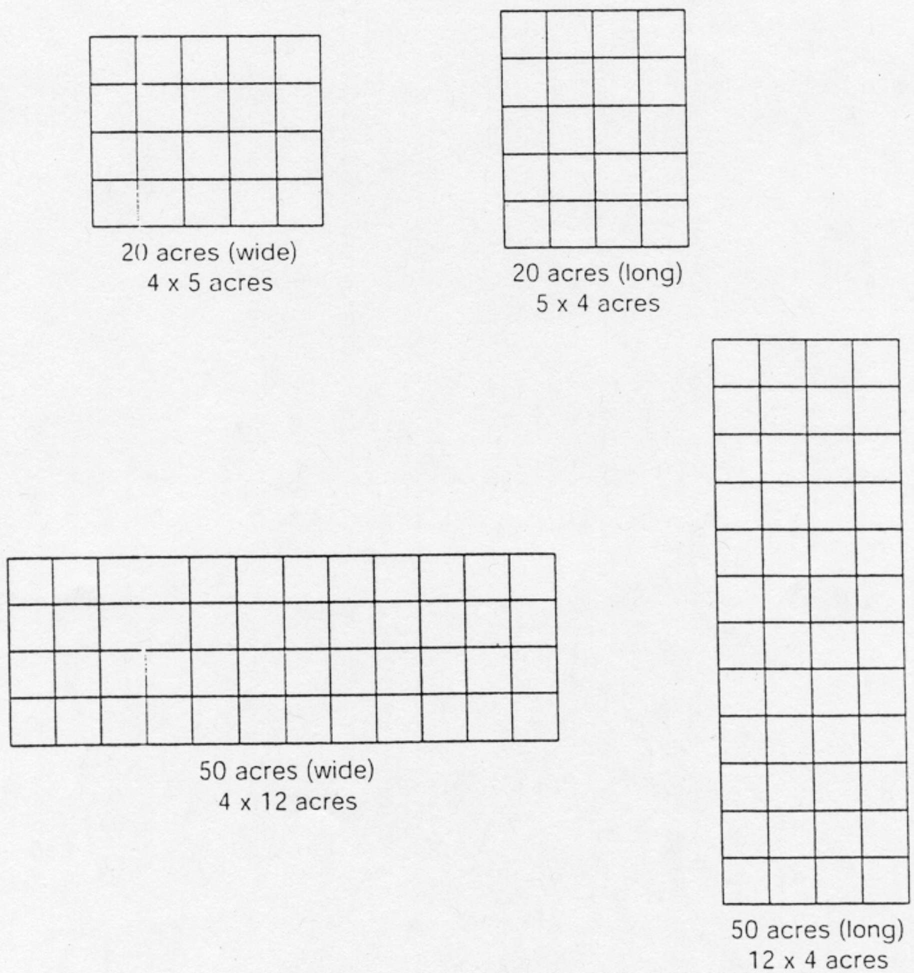
To calculate actual noise levels over distance from the source, the noise level for the proposed firing conditions was estimated at the reference distance of 100 feet using the assumption of 100 dBC for two detonation cords of 100 foot length detonated between one and three feet below the surface. Using this level, a sub-element of 25 feet of detonation cord was defined as having a blast noise level of 91 dBC. All calculations considered each sub-element as a point-source of noise and the summed noise contribution from the sub-element (Figure 1). The noise levels for each source were then propagated to the distance of interest using noise propagation equations.

The noise levels were modeled for each individual sub-element using a soft site attenuation factor with a 7.5 dB reduction per doubling of distance. This is a typical attenuation factor derived from energy dispersion equations (6 dB reduction per distance doubling) with an empirical correction to account for effects of the ground (1.5 dB reduction per distance doubling). The noise levels for all sub-elements were then integrated. No additional shielding from terrain or vegetation was included to assure that the analysis was highly conservative. If there is substantial forested area between the source and receiver, actual noise levels could be reduced by up to 5 dB the first 100 feet and another 5 dB for the second 100 feet with the benefits decreasing beyond 200 feet of shielding. Actual noise levels may be reduced by as much as 10 dB at the site of interest as a result of shielding provided by terrain and vegetation between the source and receiver.

Figure 1



The other four sources that were considered:



In this study, five different blast area configurations (based on the length and configuration of the detonation cords employed) were used to estimate the resulting noise levels to the distance. The five configurations shown in Figure 1 consist of 1,000 feet of detonation cord over a 1 acre area; 20,000 feet of detonation cord over a 20 acre area (4 by 5 acres and 5 by 4 acres); and 50,000 feet of detonation cord over a 50 acre area (4 by 12 acres and 12 by 4 acres).

Results

Noise levels over distance from each source were calculated. The results of the calculations are show in Table 1. As shown in the table, 1,000 linear feet of detinaiton cord spread over a 1 acre area would result in a noise level of 101 dBC at 100 feet from the edge of the blast given the source level assumptions that have been incorporated into this analysis. At greater distances from the source, the level would be less, while for a larger blast area, and likewise more detinaiton cord, the level would be greater. For example, at 3,000 feet from a one-acre blast the noise level would decrease to 70 dBC; however, if the blast area were to be increased to 20 scres, the noise level at 3,000 feet would be 83 dBC. Receivers at diagonal distances from each blast configuration (Figure 1) would experience noise levels between the wide and long confiurations.

Conclusion

For the known eagle's nest located approximately 1000 feet diagonally from the Lake Davis greatest blast area (surface of Lake Davis at 5775 feet), maximum noise levels would be approximately 94 dBC for a 20 acre blast and 96 for a 50 acre blast, neglecting additional shielding from vegetation. The shielding could reduce the noise levels by as much as 10 dBC.

Neglecting additional shielding from vegetation, the known eagle's nest located approximately 3000 and 4000 feet diagonally from the Lake Davis medium (surface of Lake Davis at 5767.5 feet) and smallest (surface of Lake Davis at 5762 feet) blast area the maximum noise levels would be substantially reduced. The maximum noise levels would be between approximately 83 and 80 dBC for a 20 acre blast and 86 and 83 for a 50 acre blast, respectively. Again, shielding provided by vegetation and terrain could reduce the noise levels by 10 dBC.

Table 1: Estimated Noise Levels

Distance (ft)	1 Acre (dB)	20 Acres wide (dB)	20 Acres Long (dB)	50 Acres wide (dB)	50 Acres Long (dB)
100	101	106	107	106	107
200	96	103	103	103	104
300	92	100	101	101	102
400	90	99	99	99	101
500	88	97	98	98	100
600	86	96	97	97	99
700	85	95	96	96	99
800	83	94	95	95	98
900	82	94	94	94	97
1,000	81	93	94	94	97
1,500	77	89	90	91	93
2,000	74	87	87	88	91
2,500	72	84	85	86	89
3,000	70	83	83	85	87
3,500	68	81	82	83	85
4,000	67	80	80	82	84
4,500	65	79	79	81	83
5,000	64	78	78	80	82
5,500	63	77	77	79	81
6,000	62	76	76	78	80
6,500	62	75	75	77	79
7,000	61	74	74	77	78
7,500	60	73	74	76	78
8,000	59	73	73	75	77
8,500	59	72	72	75	76
9,000	58	71	72	74	76
9,500	57	71	71	74	75
10,000	57	71	71	74	75

SUPPLEMENTAL BIOLOGICAL ASSESSMENT
LOCK & DAM 24 REHABILITATION: EXPLOSIVE CONCRETE REMOVAL

U.S. Army Corps of Engineers, St. Louis District

November 2000

INTRODUCTION

A Biological Assessment (BA) was prepared for the Major Rehabilitation of Lock and Dam No. 24 and provided to the U.S. Fish and Wildlife Service for review on 10 February 1997. The Service concurred with the BA and indicated that "the proposed activity is not likely to adversely affect any listed or proposed threatened or endangered species." (U.S. Army Corps of Engineers 1997a, 1997b; U.S. Fish and Wildlife Service 1997). The Service also indicated that "should the project be modified or new information indicates endangered species may be affected, consultation should be initiated." At the time the Biological Assessment was prepared, exact details of the demolition methods were not know. Subsequently, various demolition techniques were evaluated and it was determined that the use of explosives for concrete removal was the most time and cost-effective method available. The purpose of this Supplemental Biological Assessment is to evaluate the effects of explosive concrete removal on the bald eagle. All other facets of the project remain essentially the same as outlined in the original Biological Assessment.

Blast overpressure (noise) is the sharp instantaneous rise in ambient atmospheric pressure resulting from an explosion. Occupationally, it is also described as high-energy impulse noise. Blast-induced injury is traditionally divided into three broad categories (Elsayed 1997; Lavonas 2000): 1. *primary blast injury* is caused by the direct effect of blast overpressure on the organism. Air is easily compressible by pressure, while water is not. As a result, a primary blast injury almost always affects air-filled structures such as the lung, ear and GI tract; 2. *secondary blast injury*, is caused by flying objects that strike the organism; 3. *tertiary blast injury*, occurs when an organism flies through the air and strikes other objects.

IMPACT ASSESSMENT

Primary Blast Injury

There are two areas of concern with respect to exposure to blast overpressures from the proposed concrete removal. The first area of consideration is mortality associated with internal organ damage. The LD50 overpressure for birds exposed to an open-air blast is 20 pounds per square inch - psi (197 decibels - dB) (Damon et al. 1974, as reviewed in O'Keeffe and Young 1984; Yelverton et al. 1973).

The second area of consideration is the potential impact of blasting noise on the hearing of bald eagles in the vicinity of the blasting project. There are currently no publications relating peak overpressure levels resulting from blasting to bird auditory system damage. There are limited data on acoustic trauma to birds, little information on species-specific susceptibility to noise (Ryals et al. 1999), and absolutely no information on the susceptibility of bald eagles to acoustic trauma. However, there are established safety values for humans exposed to blasting noise and it has been suggested that birds are less susceptible than mammals to both Temporary Threshold Shifts (TTS) and Permanent Threshold Shifts (PTS) resulting from impulse noise (Saunders and Dooling 1974). An impulse noise level of 5-10 psi (approximately 185-191 dB) is considered dangerous to human hearing (Kerr 1978; Lavonas 2000; James et al. 1982, as reviewed in Garth 1994).

The blasting contractor will be required to keep overpressure values below 128 dB (0.0073 psi) (measured on a calibrated system) at a distance of 400-feet (ft) from the blast. A 134 dB level is a standard safety level established by the U.S. Bureau of Mines (Siskind et al. 1980) and recommended or required in many states to protect structures from any noise damage (Schneider et al. 2000). The most recent survey of bald eagles at Lock and Dam 24 (Harper 1983) indicated that the nearest bald eagle foraging, day resting, and eating areas (Figure 6 in Harper 1983) were all approximately 0.5 kilometer (km, 1,600 ft) from the blasting site. These survey data are approximately two decades old but would indicate that major areas of bald eagle activity are not in the immediate vicinity of the blast site. The 128 dB level previously noted in the immediate area of the blast site would have attenuated to approximately 124dB (0.0046) at 0.5 km distance. Thus, the actual overpressure exposure level would be less than what is currently considered to be non-injurious.

The areas of high eagle activity indicated by Harper (1983) were substantiated in a conversation with Karen Watwood (U.S. Army Corps of Engineers, Riverlands Office) She indicated that most eagle activity occurs on the Illinois side of the river below the spillway and south of the boat club on the Missouri side of the river. The only time the eagle come closer to the blasting site is during feeding by individuals in the early morning (7-9 a.m.) and late afternoon (2:30-4:30 p.m.).

In order to ensure the safety of the bald eagle, the blasting contractor will not be allowed to initiate an explosion when eagles are within 500 ft of the blast zone, which corresponds to the 128dB (0.0073 psi) level. As long as bald eagles are beyond this distance, there is little chance of internal organ damage, mortality, or hearing damage resulting from the use of explosives during the rehabilitation of Lock and Dam 24.

Based on the established "safety zone" and the extremely high-pressure level required to cause bird mortality (197 dB, 20 psi) and the rapid attenuation of pressure in air (Mellor 1985), no internal damage or mortality are expected from the blasting operation. Using the noise levels considered damaging to human hearing (185-191 dB, 5-10 psi) as a surrogate for bird hearing damage levels, it is suggested that the proposed project will have no effect on bird hearing. Although no impacts on hearing are anticipated, it should also be noted that relatively severe acoustic overexposures that would lead to irreparable damage and large PTSs in mammals are moderated in birds by subsequent hair cell regeneration (Cotanche 1987a; Cotanche and Corwin 1991; Niemiec et al. 1994) and repair to the tectorial membrane and other structures (Cotanche 1987b; Adler et al. 1993; Adler et al. 1995). Should an accidental overexposure occur, and this is not anticipated, it is likely that hearing would be restored in a short period of time

Secondary Blast Injury

Secondary blast injury would occur if bald eagles were hit by flyrock. The blasting area is near the Lock & Dam 24 office and Clarksville, MO. Every precaution will be taken to eliminate flyrock . The blast site will be covered, as necessary, with blasting mats, a standard technique utilized in the blasting industry to eliminate flyrock. In addition, the 500-ft eagle no-fly zone (safety zone) surrounding the blast site will further protect the eagles from any flyrock. If eagles are observed in the 500-ft safety zone, shots will be halted until they have left the area.

Tertiary Blast Injury

Tertiary blast injury would occur only if a bald eagle were knocked from the air by the force of the blast. Again, the 500-ft safety zone (eagle no-fly zone) will eliminate this potential.

Disturbance

A potential impact of the blasting operation is the possibility that bald eagles could be "frightened" by the blast, take flight, and use up important energy stores. "Fright-flight" would be considered harassment under the Endangered Species Act. There currently is little information concerning the response of bald eagles to blasting. Stalmaster and Newman (1978) indicated that bald eagles did react to gunshots.

> "Normally occurring auditory disturbances were not unduly disruptive to eagle behavior....... Gunshots were the only noises that elicted overt escape behavior...Eagles were especially tolerant of auditory stimuli when the sources were partially or totally concealed from view."

In a four-year study, Russel et al. (1993, as reviewed in Larkin et al. 1996) suggested that there was no significant difference in bald eagle nesting success at the Aberdeen Proving Ground, Maryland, when compared with the National average of 0.92 young per nest. Aberdeen is a test facility where weapons firing is a common occurrence, including weapons up to the 203-mm howitzer. Aberdeen is also intensively used by bald eagles for nesting and roosting.

Although it is not known exactly what effect blasting will have on bald eagle flight, previous observations might suggest possible responses. During an explosive testing program at Carlyle Lake, Illinois, gulls not only habituated to the blasting program but also responded to each blast by immediately flying to the area to feed on dead gizzard shad (Keevin, personal observation).

There has been a considerable amount of published information (mostly observational) relative to the effect of explosions on fish behavior. Although fish are certainly not bald eagles, their response may give some clues to how organisms react to an impulse noise. Keevin et al. (1997) found that radio-tagged largemouth bass, channel catfish and flathead catfish moved very little in response to "repelling charges" that are used by the blasting industry to frighten and drive fish away from a blasting zone prior to detonation of a major demolition charge. These results compare with other observations of fish in response to blasting (Knight 1907; Fitch and Young 1948; Cooker and Hollis 1950; Hubbs and Rechnitzer 1952; Nix and Chapman 1985; Ross et al 1985). For example, Ross et al. (1985) made observations of the response of American sand lance (Ammodytes americanus) schools to explosions. In response to a blast, all members of the school under observation altered course for approximately 1 to 2 seconds, before resuming their original orientation and movement patterns. There was no flight response.

Although fish are obviously not birds, a similar response might be expect by the bald eagle, an initial startle response followed by a return to the previous activity. This is also a common response in humans to loud impulse noises (i.e., engine backfires. car crash sounds) and fireworks (i.e., firecrackers, cherry bombs, M-80s, etc) on the Fourth of July, an initial startle response or jump and then a return to the on-going activity.

MITIGATION MEASURES

In order to reduce the potential impact of blasting and to protect the bald eagle, the following measures will be undertaken prior to blasting.

1. Blasting mats will be used, as necessary, to cover concrete to be removed in an effort to limit fly-rock.

2. The two dam gates nearest the lock (blasting area) will be closed at least 1 hr prior to blasting to eliminate fish from moving through the gate. Stunned and disoriented fish passing through the dam gates are a major winter food source for eagles, and the reason eagles would be in the immediate vicinity of the blasting area.

3. An eagle spotter will be provided by the Government to signal an all clear prior to shot initiation. The shot may not be initiated without the all clear from the eagle spotter. Blasting will be halted if eagles are within 500 ft of the blasting zone. Blasting will resume after the eagle(s) has/(have) moved outside of the blasting zone into what is considered the "safe zone".

4. Bald eagles will be observed during a series of demolitions shots to determine their behavioral response to the explosive demolition activities. These results will be reported to the U.S. Fish and Wildlife Service.

CONCLUSION

Based on the best scientific information available, and avoid and minimize (mitigation) measures to be taken to protect the bald eagle, it appears that eagles will not be affected by primary, secondary or tertiary blast injury (e.g., fly-rock. impulse noise. or aerial displacement) associated with the blasting operation. Short-term behavioral alteration may occur (i.e., startle response), but it is anticipated that this response will be short-term and have, at most, only minor energy costs associated with it.

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6/12/01

You have been identified as one of a very small group of people in the world with experience in the use of detonation cord underwater to kill fish. A similar project is being planned in northern California to kill spawning northern pike in Lake Davis.

Your assistance in evaluating the "in air loudness" of detonation cord used underwater is needed for an environmental impact assessment of the potential noise effect on wildlife. First we will need a little information about yourself and your experience with detonation cord to kill fish. Then we would like you to estimate how loud the noise was in the air in comparison to a number of standard reference sounds. Fill in the form to the best of your ability and do not hesitate to call or email me if you have any questions.

Name ______________________ Title ______________________

Organization ______________________

Address ______________________

____

Telephone No. ______________ E-Mail ______________

Have you used detonation cord underwater to kill fish? ______________

When ? ______________________

Where? ______________________

What kind? Grains per foot, manufacture etc? ______________

____

How deep was it in the water? ______________________

Describe the bottom and banks ______________________

____

What was the estimated fish kill range? ______________________

Strategic Environmental ____________________

How many times did you use it? ____________________

Was the sound muffled by the water? ____________________

Did you use ear protection on the first detonation?____________________

How far away did you position yourself for the first detonation? ____________________

Subsequent detonations? ____________________

Did you use ear protection for subsequent detonations? ____________________

How loud was the sound of the detonation in the air? Use the attached figure for reference. ____________________

Is there another way you would care to describe the loudness of the detonation cord?

____

Was the sound in the air less than 120 dBA, (a jet taking off at 200 feet)?____________________

Do you know of other people with similar experience that we could contact?

____

____

____

Signature ____________________ Date ____________________

Would you like to be informed about the results of this survey____________________

Thank you very much,

Robert R. Abbott, Ph.D.
President

Transportation Sources	Noise Level (dBA)	Other Sources	Description
	130		Painfully loud
	125		
Jet takeoff (200 feet)	120		
Car horn (3 feet)	115		Maximum vocal effort
	110		
	105		
	100	Shout (.5 feet)	
	95		Very anoying
Heavy truck (50 feet)	90	Jack hammer (50 feet) Home shop tools (3 feet)	
Train on a structure (50 feet)	85	Backhoe (50 feet)	
	80	Bulldozer (50 feet) Vacuum cleaner (3 feet)	Anoying
Train (50 feet) City bus at stop (50 feet)	75	Blender (3 feet)	
Freeway traffic (50 feet)	70	Lawn mower (50 feet) Large office	
Train in station (50 feet)	65	Washing machine (3 feet)	Intrusinve
	60	TV (10 feet)	
Light traffic (50 feet)	55	Talking (10 feet)	
Light traffic (100 feet)	50		Quiet
	45	Refrigerator (3 feet) Bedroom	
	40	Library	
	35		
	30	Soft whisper (15 feet)	Very quiet

Sources: FTA, 1995; U.S. EPA, 1974; U.S. CEQ, 1970